THE CHEMICAL COMPOSITION OF CLUSTER IDPs USING THE XRF-MICROPROBE: G. J. Flynn[1] and S. R. Sutton[2] 1) Dept. of Physics, SUNY-Plattsburgh, Plattsburgh, NY 12901, 2) Dept. of Geophysical Sciences, The University of Chicago, Chicago, IL 60637.

Interplanetary dust particles (IDPs) are collected from the Earth's stratosphere by impact onto a rigid collection surface, covered with a thin layer of silicone oil, carried by a high-speed aircraft. This collection process separates the IDPs into two types, based crudely on structural strength: 1) those which remain intact, and, 2) those which fragment on collection (called "cluster particles"). Cluster particles are recognized by a high concentration of fragments in a small region on the collector surface. The pre-collection size of a cluster particle cannot be reconstructed unambiguously because the porosity between individual fragments is unknown.

We previously determined the element abundances in 8 cluster fragments from the L2009 collector using the XRF-Microprobe at the National Synchrotron Light Source at Brookhaven National Laboratory [1]. Each of these cluster fragments showed enrichments of the volatile elements Cu, Zn, Ga, Ge, and Se, with element/Fe ratios ranging from 2 to 6 times the CI values. The results suggested that the L2009 cluster particles are chemically distinct from the large (>35 micron) IDPs collected intact, which have a CI-like volatile pattern [2], and might even be more volatile rich than the small (~10 micron) IDPs previously studied. Messenger et al. [3] reported that deuterium enrichments in cluster particles are "larger, more common, and have higher variability than previously measured IDPs." Thus, both the chemical and the isotopic evidence suggests the cluster particles are unusual.

To determine if the cluster fragments from other stratospheric collectors are chemically similar to the L2009 cluster fragments, we have measured the Fe normalized abundances of S, Ca, Ti, Cr, Mn, Fe, Ni, Cu, Zn, Ga, Ge, Se, and Br in 6 cluster fragments from the L2005 collector [L2005C41, L2005C42, L2005D36, L2005E42, L2005F40, and L2005H51] using the XRF-Microprobe.

Five of these six fragments have element abundance patterns consistent with the chondritic IDPs previously analyzed. The sixth, L2005C42, has unusually high Cr/Fe and Mn/Fe ratios, and the lowest S/Fe, Zn/Fe, and Ge/Fe ratios in this group of fragments. However, the Ni/Fe ratio in this fragment is consistent with chondritic.

These six fragments appear somewhat different from the L2009 fragments previously examined. Two of the six fragments show severe depletions of Zn (Zn/Fe <0.2xCI), while each of the remaining four fragments have Zn/Fe within 30% of the CI ratio, while 5 of the 8 L2009 fragments exhibited Zn/Fe >CI. The average contents of the other volatile minor elements Cu, Ga, Ge, Se, and Br are enriched relative to CI, a pattern seen in most IDPs, but the average enrichments are not as large as for the L2009 particles.

L2005C41: The L2005C41 fragment is a low-Zn, chondritic fragment. The Zn/Fe ratio = 0.19 suggests this fragment experienced significant heating, most likely on atmospheric entry. Sulfur is also slightly depleted in this particle (S/Fe = 0.7xCI). However, each of the other volatile trace elements is >CI.

L2005C42: The L2005C42 fragment is unusual in that Ti, Cr, and Mn are overabundant relative to Fe compared to the CI ratios [Ti/Fe = 2.1xCI, Cr/Fe = 4.7xCI, and Mn/Fe = 9.9xCI]. However, Ni/Fe = 0.76 in this fragment, a value consistent with the chondritic ratio. Sulfur, Zn, and Ge are all <CI in this fragment in a depletion pattern consistent with that observed for particles which were severely heated, presumably on atmospheric entry. The other volatile minor elements measured (Cu, Ga, Se, and Br) are enriched relative to CI.

L2005D36: The L2005D36 fragment shows small depletions of Zn and Ge relative to CI but the other volatiles show the factor of two enrichments typically seen in IDPs, and the more refractory elements are present in the CI ratios to Fe.

L2005E42: All elements/Fe ratios measured in L2005E42 are within 30% of the CI ratios

except Cu and Br which are enriched to Cu/Fe = 2.8xCI and Br/Fe = 4.3xCI, and S and Ca, which are both depleted to 0.6xCI.

L2005F40: The L2005F40 fragment contains S, Ca, Cr, Mn, Ni, Zn, Ga, and Se all within 30% of the CI ratios to Fe, with enrichments in Ti (Ti/Fe = 1.6), Cu (Cu/Fe = 2.2) and Br (Br/Fe = 31), the largest Br/Fe ratio in this group of particles, and a depletion in Ge (Ge/Fe = 0.6).

L2005H51: The L2005H51 fragment has chondritic refractory/Fe ratios, but it shows the largest overall enrichment in the volatile elements of any of the L2005 fragments included in this study (Cu/Fe = 3.3xCI, Zn/Fe = 1.3xCI, Ga/Fe = 5.5xCI, Ge/Fe = 1.7xCI, Se/Fe = 4.2xCI, and Br/Fe = 19.5xCI).

The four L2005 cluster fragments which have ~CI levels of Zn, suggesting they have experienced little chemical alteration on atmospheric entry, are, on average, enriched in the volatiles Cu, Ga, Ge, Se, and Br relative to the CI abundances. Copper/Fe ranges from 2.2 to 3.8, Zn/Fe from 0.7 to 1.3, Ga/Fe from 1.0 to 5.6, Ge/Fe from 0.5 to 1.7, Se/Fe from 0.8 to 4.2 and Br/Fe from 4.3 to 31. These enrichments are similar to those previously reported for the smaller IDPs [4], but are a ~50% lower than the enrichments reported in the 7 L2009 cluster fragments [1]. Only L2005H51, the most volatile rich of the fragments from L2005 included in this study, has a volatile content similar to the L2009 fragments previously studied.

The apparent differences in the volatile contents of particles from the L2009 and L2005 collectors may simply reflect statistical fluctuations, given the small number of fragments examined, or they may signal a difference in the chemical compositions of the IDPs collected at different times. Examination of the JSC Cosmic Dust Catalogs provides clear evidence for the time variation of particles exhibiting distinctive morphological features. For example, particles with whisker-like crystals projecting from them, such as L2011N1 and L2011O4, are relatively common on the L2009, L2011, and W7029 collectors but rare or non-existent on most other cataloged stratospheric collectors. In addition, particles resembling aggregates of spheres, such as U2015C13 and U2015C24, occur frequently on the U2015 collector [5] but are otherwise uncommon. Kortenkamp et al. [6] have modeled the orbital evolution of dust particles from the Themis and Koronis families, which are associated with the main-belt dust bands seen in the infrared, and find a seasonal variation in the Earth collection rate of particles from these sources. For particles from Themis they find peaks in the Earth collection rate occurring in April-May and October-November [6].

The L2005 collector sampled the Earth's stratosphere for ~40 hours during the October of 1989, while the L2009 collector sampled the stratosphere for ~36 hours in June and July of 1991. The L2009 collection period overlaps the eruption of the Mt. Pinatubo volcano, on June 14-15, 1991, and there is evidence that the aerosol cloud from Mt. Pinatubo spread to 30 N. Latitude within a few weeks of that eruption [4], however the measurement of high D/H ratios [3] in fragments of several of the same L2009 clusters we examined, as well as the chondritic Ni/Fe ratios in all of these L2009 fragments, confirms their extraterrestrial origin.

Further measurements on cluster fragments from the L2006 collector, flown simultaneously with the L2005 collector, and cluster fragments from the L2011 collector, flown over the same time interval as the L2009 collector, are in progress.

References:

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